REMARKS

This paper responds to the non-final Office action dated June 21, 2006, in which (i) claims 46-105 were rejected, (ii) the reissue oath/declaration was noted as defective, and (iii) the written consent of the assignee was noted as improper.

Claims 67, 74-77, and 81-105 were indicated as allowable in substance, for which the applicants express their appreciation.

I. Status of Claims

Claims 46-105 remain pending and at issue.

By the foregoing amendments, claims 46-50, 52, 72, 74-81, 84-86, 89-91, 95, 96, 99, 100, 101, 104, and 105 have been amended.

The status of the claims is as follows:

Cancelled: Claims 1-45;

Amended: Claims 51, 53-55, 57-66, 68-71, 73, 84, 85, 89, 90, 94, 95, 99, 100, 104, and 105;

Twice Amended: Claims 50, 52, 72, 74, 75, 81, 86, 91, 96, and 101;

Thrice Amended: Claims 46, 47, 48, 49, 56, 67, and 76-78;

Four Times Amended: Claims 79 and 80; and,

Previously Added: Claims 82, 83, 87, 88, 90, 92, 93, 97, 98, 102, and 103.

II. Reissue Oath/Declaration

Applicants respectfully defer submission of a supplemental oath/declaration in accordance with the previous arrangement and understanding between former counsel for the applicants (Ms. Linda Deschere) and Examiner Evans and SPRE Tierney. During a telephone conference on June 21, 2005, deferral of the supplemental oath/declaration submission until all claims are indicated as allowable was found acceptable, for which the applicants and their undersigned attorney express their appreciation.

If the applicants' current understanding of the previous arrangement is inaccurate, the examiner is respectfully requested to contact the undersigned attorney.

III. Assignee Consent

The applicants submit herewith a copy of a paper establishing the consent of the assignee, the Regents of the University of Michigan, to the filing of the present reissue application. The applicants accordingly submit that the attached "Consent of Assignee" is in compliance with both 37 C.F.R. §1.172(a) and 37 C.F.R. §3.73.

Reconsideration and withdrawal of the objection are respectfully requested.

IV. Summary of Claim Amendments

By the foregoing amendments, claims 46-50, 72, 74-77, 80, 81, 84-86, 89-91, 94-96, 99-101, 104, 105 have been amended to address a number of typographical, grammatical and other formalities. Issues relating to establishing proper antecedent basis have been addressed in claims 46-50, 81, 86, 91, 96, and 101 in connection with the recitation of "a non-biologic material," and in claims 48-50, 86, 91, 96, and 101 in connection with the recitation of "a pulsed laser beam." Dependent claims 76, 77, 84, 85, 89, 90, 94, 95, 99, 100, 104, and 105 have been amended to remove a typographical repetition of the phrase "according to" in each preamble. Dependent claims 72, 76, 89, 99 and 104 have been amended to clarify that the repetition rate is a rate of the beam. Dependent claims 74 and 75 have been amended to address the syntax of the recited characteristics of the one or more pulses ("each having a pulse ..."). Claim 80 has been amended to address a typographical error in specifying which layer is not substantially affected. Claim 81 has been amended to address two formalities in the preamble, namely that the ablating or property changing is by laser induced breakdown, and the method comprises the following steps. No new matter has been added via these amendments.

Independent claims 46-50, 78-80, and 101 have also been amended to specify that a beam is configured such that a first area within a spot size of the beam exceeds a breakdown threshold and such that a second area within the spot size does not exceed the breakdown threshold. No new matter has been added by this amendment, as support can be found in the application as originally filed in, for example, the depiction in Fig. 5 of a spot size having an ablated area within the spot size and a further area within the spot size that is not ablated, as well as at col. 5, lines 63-66, and col. 6, lines 27-41 (U.S. Patent No. 5,656,186).

Independent claims 50 and 101 have also been amended to specify that the relationship of fluence breakdown threshold is nearly constant over a pulse width range, and that a beam is generated in which at least one pulse has a pulse width within the pulse width range. No new matter has been added by this amendment, as support can be found in the application as originally filed in connection with, for example, Fig. 3 and Example 1, and at col. 5, lines 42-46 (U.S. Patent No. 5,656,186).

Dependent claim 52 has been amended to specify that the material comprises an integrated circuit material. No new matter has been added by this amendment, as support can be found in the application as originally filed at, for example, col. 11, lines 31-34 (U.S. Patent No. 5,656,186).

V. <u>Rejections under 35 U.S.C. §112</u>

Claim 52 stands rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the written description requirement.

The applicants respectfully submit that the rejection has been rendered moot by the foregoing amendments to claim 52 removing the recitation of a semiconductor material. As amended, claim 52 recites that the material comprises an integrated circuit material, for which explicit support can be found in the application as originally filed as set forth above.

Reconsideration and withdrawal of this rejection of claim 52 are respectfully requested.

Claims 54, 56, 59-61, 66, 67, 78, 79, 80-100, and 101-105 stand rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement. The rejection is based on the assertion that the specification does not teach how to direct a beam to a point "in the material" or "beneath the surface of the material" other than via a focusing step.

The applicants respectfully traverse the rejection and the underlying assertion, and further respectfully request reconsideration based on the following remarks and attached reference.

The applicants submit that the specification expressly teaches and references known alternative techniques to direct the beam to a point in the material and to a point beneath the

surface of the material. As described below, the specification enables one skilled in the art to direct the beam to a point without lens-based focusing, as well as how to direct the beam to points in a material or beneath the surface.

The specification refers to well-known techniques for directing a beam to a point without lens-based focusing. Alternative embodiments are expressly described at col. 6, lines 41-50, including a reference to the well-known Fourier transform shaping technique.

Fourier transform shaping is a well-known technique for configuring a beam in an arbitrary, geometric shape. Indeed, Fourier transform shaping is described in the present specification as a technique for achieving a desired beam configuration, noting specifically, "desired beam configurations are achieved ... through Fourier Transform (FT) pulse shaping to cause a special frequency distribution to provide a geometric shape" (col. 2, line 65 – col. 3, line 2).

As set forth in the applicants' previous response, Fourier transform shaping does not rely on a lens or focus. Please see, for example, the textbook entitled Optics, by E. Hecht and A. Zajac (1974, Addison-Wesley), excerpts from which were enclosed therewith. Instead, Fourier transform shaping relies on the application of Fourier transform mathematics to the behavior of light in the presence of boundaries. This basic concept is addressed in the introductory chapters of Joseph W. Goodman's textbook entitled *Introduction to Fourier Optics* (1968, McGraw-Hill Book Co.). Subsequent chapters in this edition were directed to "Fourier Transforming and Imaging Properties of Lenses" (Chapter 5), "Frequency Analysis of Imaging Systems" (Chapter 6), and "Wavefront-Reconstruction Imaging, or Holography" (Chapter 8). The Goodman textbook has recently been published in its third edition.

Goodman teaches how a particular type of mask can shape a beam and, in a rather simple example, act as a lens. For example, in an exercise provided at the end of Chapter 5, Goodman shows that the well-known diffracting screen, the Fresnel Zone Plate, is one type of mask that "acts as a lens with multiple focal lengths." Please see Problem 5-10 on pages 99-100 of Goodman, an excerpted copy of which is attached hereto. In short, the diffracting screen implements a Fourier transform in accordance with the Fourier series shown on page 100 to configure a beam just as a lens would.

Thus, Fourier transform shaping techniques can provide a well-known substitute for lens-based focusing. That is, directing the beam shaped by Fourier transform techniques achieves the exact same results as lens-based focusing.

The Office action recognizes that lens-based focusing is described in the specification as a technique for directing the beam "in the material" or "beneath the surface of the material" (Office action, p. 4). Because Fourier transform shaping can be implemented to act just as a lens does, it follows that Fourier transform shaping can also direct the beam in exactly the same manner, i.e., "in the material" or "beneath the surface of the material."

Based on the foregoing, the applicants respectfully submit that the specification enables one of ordinary skill in the art to direct the beam in the material and beneath the surface of the material in ways other than lens-based focusing. The applicants accordingly submit that the above-referenced claims are in compliance with the enablement requirement of 35 U.S.C. §112, first paragraph.

VI. Rejections under 35 U.S.C. §§102(b), 102(e), and 103(a)

Claims 46-66, 68-73, and 78-80 stand rejected under either 35 U.S.C. §§102(b), 102(e) or 103(a) as anticipated or unpatentable over one or more of Sherman et al. ("Transient response of metals to ultrashort pulse excitation"), Schwab et al. ("Femtosecond-Excimer Laser Patterning of $YBa_2Cu_3O_7$ Films"), Alexander U.S. Patent No. 6,489,589, Lai U.S. Patent No. 5,984,916, Mourou et al. U.S. Patent No. 5,235,606, and Wojnarowski et al. U.S. Patent No. 5,104,480 (collectively, "the cited art").

Reconsideration and withdrawal are respectfully requested, as the applicants submit that (1) the rejected claims, as amended, are not anticipated by the cited art, and (2) a prima case of obviousness has not been established. The applicants accordingly traverse the art-based rejections on at least the following grounds.

As set forth in MPEP §2131, to anticipate a claim, the cited reference must teach every element of the claim. The prior art references must also teach or suggest all of the claim limitations to establish a prima facie case of obviousness, as set forth in MPEP §2142.

Each of the independent claims 46-50 and 78-80, as amended, requires that a beam be configured such that a first area within a spot size of the beam exceeds a fluence threshold and such that a second area within the spot size does not exceed the fluence threshold.

The applicants respectfully submit that none of the cited art discloses or suggests such configuration of a beam relative to a fluence threshold.

In contrast, the Sherman reference describes the ultrashort laser pulse illumination of a metal surface, concentrating on results below the fluence threshold, rather than beam configuration with respect to areas within the spot size of the laser, much less discussion of such areas relative to the fluence threshold. The Schwab reference describes projection patterning using masks inserted into the beam path, but also without addressing beam configuration with respect to areas within the spot size of the patterning laser. The only other reference applied in an anticipatory rejection of the claims, Alexander U.S. Patent No. 6,489,589, also fails to address beam configuration with respect to areas within the spot size of the femtosecond laser beams described in general with various machining processes. For at least these reasons, none of Sherman, Schwab and Alexander describe or suggest the desirability of configuring a beam such that areas within the spot size both exceed and not exceed the fluence threshold.

None of the other cited references cure these deficiencies. Lai U.S. Patent No. 5,984,916, in fact, teaches away from operating close to a fluence threshold (see, e.g., col. 5, lines 60-65), and instead teaches wide and fine excision merely by modifying the size of the beam spot (see, e.g., col. 12, lines 55-60). Mourou et al. U.S. Patent No. 5,235,606 is directed to an exemplary technique for laser pulse generation generally, and without addressing beam configuration, let alone beam configuration relative to a fluence threshold. Wojnarowski et al. U.S. Patent No. 5,104,480 is directed to laser-based machining techniques relative to certain workpiece structures, rather than beam configuration techniques.

For at least the foregoing reasons, the applicants respectfully submit that the cited art fails to disclose or suggest configuring a beam such that a first area within a spot size of the beam exceeds a fluence threshold and such that a second area within the spot size does not exceed the fluence threshold, as recited in claims 46-50 and 78-80, as amended. It follows that claims 46-50 and 78-80 and, by implication, claims 51-66 and 68-73 dependent thereon, recite patentable subject matter over the cited art.

VII. Conclusion

For the foregoing reasons, it is submitted that all pending claims 46-105 are allowable over the cited references, and an indication to that effect is solicited.

This paper is timely filed, inasmuch as it is accompanied by a request for a three-month extension of time and the requisite fee.

Should the examiner wish to discuss the foregoing or any matter of form in an effort to advance this application toward allowance, the examiner is urged to telephone the undersigned at the indicated number.

Dated: December 21, 2006

Respectfully submitted,

By ______________________

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Attorney for Applicant

Attachments:

1. Consent of Assignee
2. J.W. Goodman, Introduction to Fourier Optics, McGraw-Hill Book Co., pp.99-100 (1968)
3. Petition for Extension of Time under 37 C.F.R. §1.136(a) and requisite fee

I hereby certify that this correspondence is being deposited with the U.S. Postal Service with sufficient postage as First Class Mail, in an envelope addressed to: MS Amendment, Commissioner for Patents, P.O Box 1450, Alexandria VA 22313-1450, on the date shown below.

Dated: December 21, 2006 Signature:
G. Christopher Braidwood

Docket No.: 30275/939A
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of:
Gerard A. Mourou et al.

Reissue Application No.: 09/775,106 Confirmation No.: 4544

Filed: February 1, 2001 Art Unit: 1725

For: Method for Controlling Configuration of Laser Induced Breakdown and Ablation Examiner: Geoffrey S. Evans

CONSENT OF ASSIGNEE

Sir:

The Regents of the University of Michigan, assignee of U.S. Patent No. 5,656,186, consent to the filing of Reissue Application No. 09/775,106, for the reissue of U.S. Patent No. 5,656,186.

The assignment for U.S. Patent No. 5,656,186, was recorded in the United States Patent and Trademark Office on September 2, 1994, at Reel 7118, Frame 0175.

The Regents of the University of Michigan have not granted an assignment to any third party in connection with U.S. Patent No. 5,656,186.

I, Ruth L. Rasor, as Director of Licensing, Office of Technology Transfer, for the University of Michigan, have the capacity to sign this "Consent of Assignee" on behalf of the Regents of the University of Michigan.

Date: 20 December 2006

Ruth L. Rasor
Director of Licensing
University of Michigan
Office of Technology Transfer

Stanford University JOSEPH W. GOODMAN
Department of Electrical Engineering

INTRODUCTION TO FOURIER OPTICS

San Francisco McGRAW-HILL BOOK COMPANY

Introduction to Fourier Optics

Library of Congress Catalog Card Number: 68-17184

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PREFACE

In writing this book I have attempted to organize a text on optics which is specifically directed toward electrical engineers. As the reader may know, several excellent books devoted to the application of Fourier analysis and linear systems concepts in optics already exist. However, it has been my experience that these previous books are best suited for physicists, who are already rather familiar with the principles of classical optics, but perhaps less familiar with the mathematical techniques which are now so fruitfully applied in the modern theory of image formation. Electrical engineers, on the other hand, are very familiar with the mathematical techniques through their extensive exposure to network analysis, but are relatively weak in the principles of classical optics. It therefore seemed reasonable to present the principles of optics to electrical engineers in a manner which makes maximum use of the mathematical tools already at their disposal. Thus Fourier analysis and linear systems theory provide the foundation on which the theory of image formation, optical data processing, and holography are constructed.

The book originated as a set of class notes for a one-quarter course on Fourier Optics in the Department of Electrical Engineering at Stanford University. The students were, for the most part, in their first or second year of graduate study. As the volume of material grew with successive revisions of the notes, it became more and more difficult to cover all the material in the 30 lectures of a single quarter. Consequently, in later versions of the course I have found it necessary to omit (or at best treat only briefly) the following sections: 2-3, 3-5, 3-6, 4-3, 6-6, 7-7, and portions of 8-8 and 8-9. For a course running a full semester, all the material can probably be included.

I am grateful to many people for their help and encouragement in this endeavor. Perhaps my deepest debt is to the members of the Radar and Optics Laboratory staff at the University of Michigan, who through their publications and through personal contact stimulated my interest

5-4 An object function U_o, bounded by a circular aperture of diameter l, is impressed across the front focal plane of a circular converging lens of diameter L. The intensity distribution is measured across the back focal plane of the lens. Assuming $L > l$:
(*a*) Find an expression for the maximum spatial frequency for which the measured intensity accurately represents the squared modulus of the object's Fourier spectrum.
(*b*) What is the numerical value of that frequency (in cycles/mm) when $L = 4$ cm, $l = 2$ cm, f (focal length) $= 50$ cm, and $\lambda = 6 \times 10^{-7}$ meter?
(*c*) Above what frequency does the measured spectrum vanish, in spite of the fact that the object may have nonzero Fourier components at higher frequencies?

5-5 A diffracting screen has a circularly symmetric amplitude transmittance function given by

$$t(r) = \left(\frac{1}{2} + \frac{1}{2}\cos \alpha r^2\right) \operatorname{circ}\left(\frac{r}{l}\right)$$

(*a*) In what ways does this screen act like a lens?
(*b*) Give an expression for the focal length of the screen.
(*c*) What characteristics might seriously limit the use of this screen as an imaging device, particularly for polychromatic objects?

5-6 An array of one-dimensional object functions can be represented by $U_o(x,y_k)$, where $y_1, y_2, \ldots, y_k, \ldots, y_N$ are N fixed y coordinates. It is desired to perform a Fourier transformation of all N functions in the x direction, yielding an array of transforms

$$G_o(f_X,y_k) = \int_{-\infty}^{\infty} U_o(x,y_k) \exp(-j2\pi f_X x)\, dx$$

Neglecting the finite extent of the lens and object apertures, use the Fourier transforming and imaging properties of lenses derived in this chapter to show how this can be done with:

(*a*) two cylindrical lenses of different focal lengths
(*b*) a cylindrical and a spherical lens of the same focal length

SIMPLIFICATION: You need only display $|G_o|^2$, so phase factors may be dropped.

5-7 With reference to the approximation of Eq. (5-29):

(*a*) At what radius r in the object plane has the factor $\exp\left[j\frac{k}{2d_o}(x_o^2 + y_o^2)\right]$ changed by exactly π radians from its value at the origin?
(*b*) Assuming a circular pupil function of radius α, what is the radius (in the object plane) to the first zero of h, assuming that the observation point in the image space is the origin?
(*c*) From these results, what relation between α, λ, and d_o will allow the phase factor $\exp\left[j\frac{k}{2d_o}(x_o^2 + y_o^2)\right]$ to be dropped, assuming observation near the lens axis?

5-8 A normally incident, unit-amplitude, monochromatic plane wave illuminates a converging lens of 5 cm diameter and 2 meters focal length. One meter behind the lens and centered on the lens axis is placed an object with amplitude transmittance

$$t(x_o,y_o) = \tfrac{1}{2}(1 + \cos 2\pi f_o x_o) \operatorname{rect}\left(\frac{x_o}{L}\right) \operatorname{rect}\left(\frac{y_o}{L}\right)$$

Assuming $L = 1$ cm and $f_o = 100$ cycles/cm, sketch the intensity distribution across the x_f axis of the focal plane, labeling the numerical values of the distance between the diffracted components and the width (between first zeros) of the individual components.

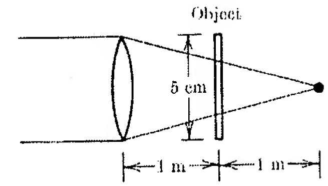

Figure P5-8

5-9 A unit-amplitude, normally incident, monochromatic plane wave illuminates an object of maximum linear dimension l, situated immediately in front of a larger converging lens of focal length f. Due to a positioning error, the intensity distribution is measured across a plane at a distance $f - \Delta$ behind the lens. How small must Δ be if the measured intensity distribution is to accurately represent the Fraunhofer diffraction pattern of the object?

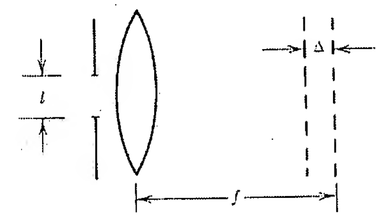

Figure P5-9

5-10 A certain diffracting screen with an amplitude transmittance

$$t(r) = \left[\frac{1}{2} + \frac{1}{2}\operatorname{sgn}(\cos \alpha r^2)\right] \operatorname{circ}\left(\frac{r}{l}\right)$$

is normally illuminated by a unit-amplitude, monochromatic plane wave. Show that the screen acts as a lens with multiple focal lengths. Specify the

size of these focal lengths and the relative amounts of energy brought to a focus in the corresponding focal planes. (A diffracting screen such as this is known as a *Fresnel zone plate.*)
HINT: The square wave shown in Fig. P5-10 can be represented by the Fourier series

$$f(x) = \sum_{n=-\infty}^{\infty} \left[\frac{\sin(\pi n/2)}{\pi n}\right] \exp\left(j\,\frac{2\pi nx}{X}\right)$$

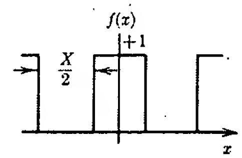

Figure P5-10

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5-1 Rhodes, J.: Analysis and Synthesis of Optical Images, *Am. J. Phys.*, **21**:337 (1953).
5-2 Cutrona, L. J., et al.: Optical Data Processing and Filtering Systems, *IRE Trans. Inform. Theory*, IT-6:386 (1960).
5-3 Preston, K., Jr.: Use of the Fourier Transformable Properties of Lenses for Signal Spectrum Analysis, in J. T. Tippett et al. (eds.), *Optical and Electro-optical Information Processing*, M.I.T. Press, Cambridge, Mass., 1965.

6 / FREQUENCY ANALYSIS OF OPTICAL IMAGING SYSTEMS

Considering the long and rich history of optics, the tools of frequency analysis and linear systems theory have played important roles for only a relative short period of time. Nevertheless, in this short time these tools have been so widely and successfully employed that they now occupy a fundamental place in the theory of imaging systems.

A realization of the utility of Fourier methods in the analysis of optical systems arose rather spontaneously in the late 1930s when a number of workers began to advocate the use of sinusoidal test patterns for system evaluation. Much of the initial stimulus was supplied by a French scientist, P. M. Duffieux, whose work culminated in the publication of a book, in 1946, on the use of Fourier methods in optics [Ref. 6-1]. Unfortunately, this book has never been translated into English and is not widely available. In the United States, much of the interest in these topics was stimulated by an electrical engineer named Otto Schade, who very successfully employed the methods of linear systems theory and communication theory in the analysis and improvement of television camera lenses [Ref. 6-2]. However, the foundations of Fourier optics were in fact laid considerably earlier than 1940, particularly in the works of Ernst Abbe (1840–1905) and Lord Rayleigh (1842–1919).

In this chapter, we shall consider the role of Fourier analysis in the theory of coherent and incoherent imaging. While historically the case of incoherent illumination has been the more important one, nonetheless the case of coherent illumination has always been important in microscope imagery and has gained additional importance since the advent of the laser. For further discussions of various aspects of the subject matter to follow, the reader may consult the books by O'Neill [Ref. 6-3], Francon